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Technical Note

1965-47

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Distribution of Look Angles to a Near Synchronous Satellite

8 September 1965

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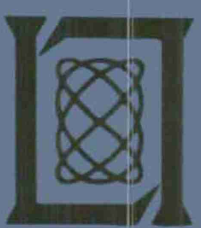

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY

LINCOLN LABORATORY

DISTRIBUTION OF LOOK ANGLES TO A NEAR SYNCHRONOUS SATELLITE

MAXINE H. SIMON

Group 66

TECHNICAL NOTE 1965-47

8 SEPTEMBER 1965

LEXINGTON MASSACHUSETTS

ABSTRACT

There is interest in determining the distribution of look angles to a near synchronous equatorial satellite for ground stations at various latitudes. A computer program was written to determine these distributions with ground station latitude and minimum acceptable look angle as parameters.

Accepted for the Air Force
Stanely J. Wisniewski
Lt Colonel, USAF
Chief, Lincoln Laboratory Office

DISTRIBUTION OF LOOK ANGLES TO A NEAR SYNCHRONOUS SATELLITE

There is interest in determining the distribution of look angles to a near synchronous equatorial satellite for ground stations at various latitudes. A computer program was written to determine these distributions with ground station latitude and minimum acceptable look angle as parameters.

The results, corresponding to minimum look angles of 0° and 10°, are plotted on Figs. 1 and 2, respectively.

Because the satellite passes directly overhead only at a ground station of 0° latitude, ground stations at higher latitudes cannot see the satellite with their antennas pointing straight up. In fact the higher the latitude of the ground station, the lower is the maximum elevation angle possible to use to sight the satellite. For example with $\theta = 10^\circ$, a station at latitude 20° can see the satellite with an elevation angle of 66.5° although only for a very short time whereas a station at 60° can see the satellite with an elevation angle of at most 22° for a very short time. Ground stations above a latitude of 71.44° cannot see the satellite at all, with an elevation angle of 10° or higher and stations above 81.3° cannot see the satellite at all with a 0° or higher elevation angle.

As the elevation angle increases, the fraction of time that an elevation angle of this size or larger can be used decreases almost linearly. As the

elevation angle reaches the maximum for that station, the fraction of time decreases at a faster rate. For example, with $\theta = 10^\circ$, a ground station at latitude 30° uses an elevation angle greater than 20°, 83.5% of the total time; an elevation angle greater than 30°, 66% of the total time; and an elevation angle greater than 50° only 26% of the total time. For a given ground station and elevation angle φ, the percentage of time that angle φ can be used to sight the satellite is slightly smaller for $\theta = 0^\circ$ than for $\theta = 10^\circ$.

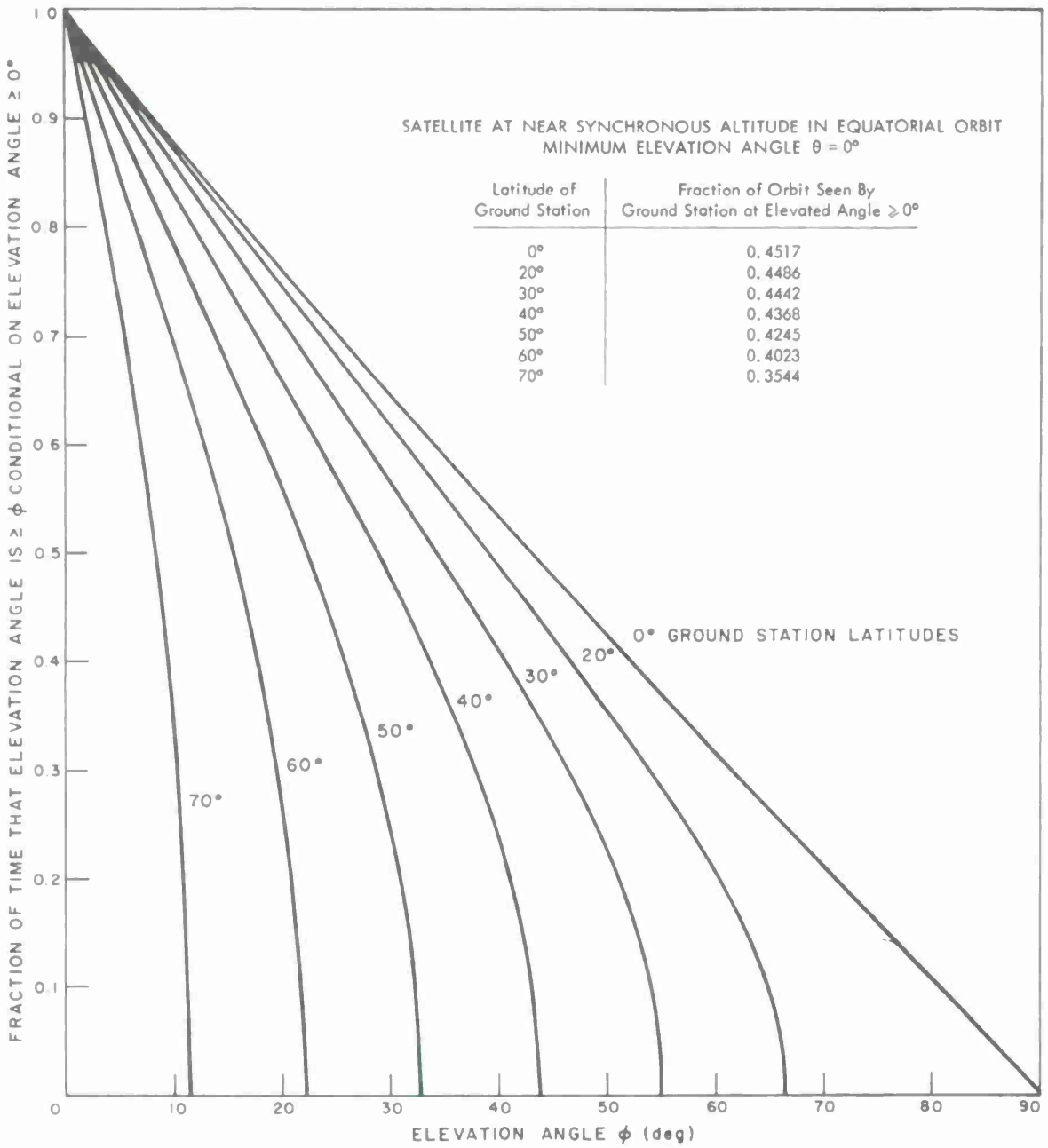
SATELLITE AT NEAR SYNCHRONOUS ALTITUDE IN EQUATORIAL ORBIT
MINIMUM ELEVATION ANGLE θ = 0°
Latitude of Ground Station
Fraction of Orbit Seen By Ground Station at Elevated Angle ≥ 0°
0° 0.4517
20° 0.4486
30° 0.4442
40° 0.4368
50° 0.4245
60° 0.4023
70° 0.3544
0° GROUND STATION LATITUDES
20°
30°
40°
50°
60°
70°
FRACTION OF TIME THAT ELEVATION ANGLE IS ≥ φ CONDITIONAL ON ELEVATION ANGLE ≥ 0°
ELEVATION ANGLE φ (deg)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
10
20
30
40
50
60
70
80
90

Fig. 1

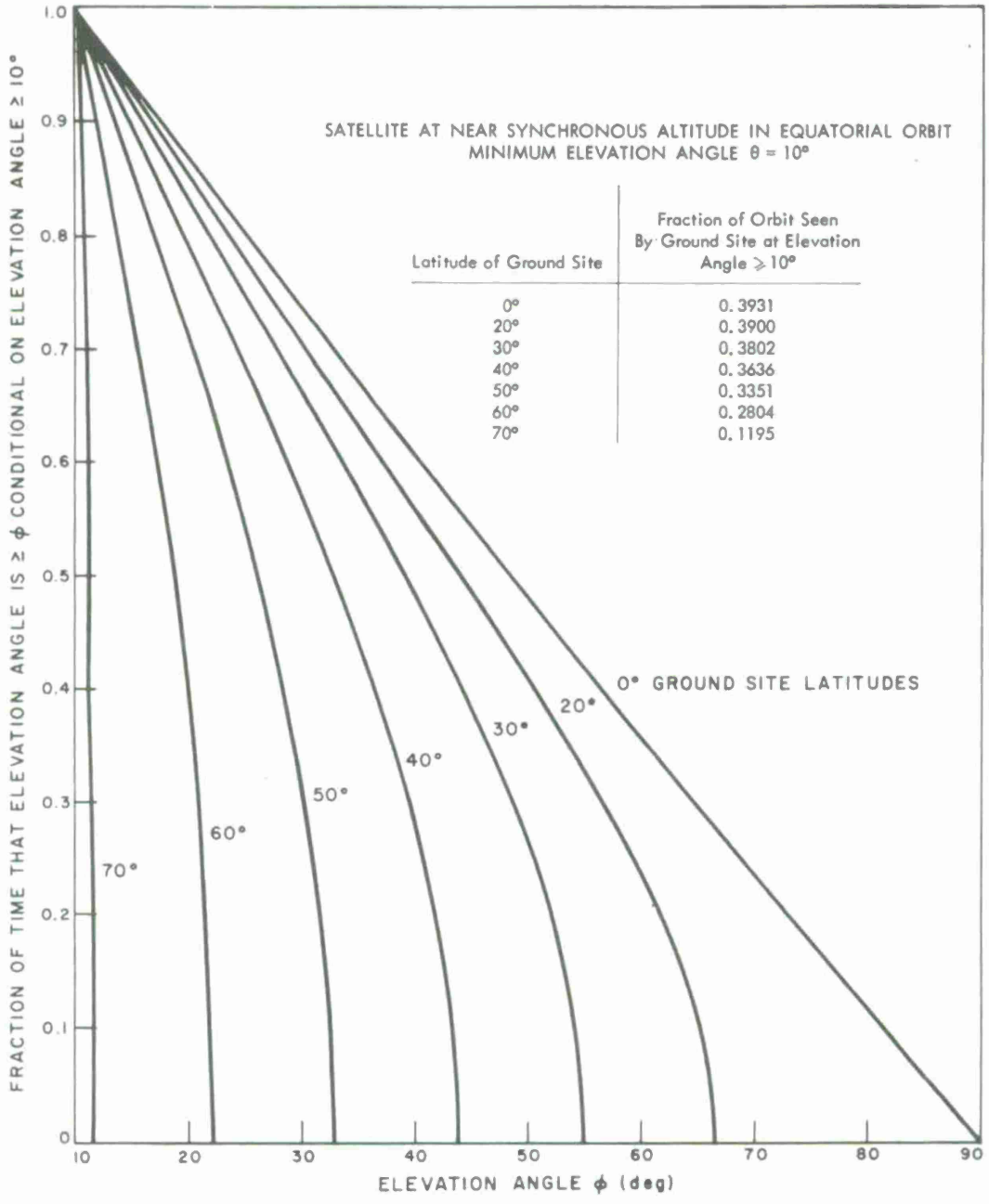
SATELLITE AT NEAR SYNCHRONOUS ALTITUDE IN EQUATORIAL ORBIT
MINIMUM ELEVATION ANGLE θ = 10°
Latitude of Ground Site
Fraction of Orbit Seen By Ground Site at Elevation Angle ≥ 10°
0° 0.3931
20° 0.3900
30° 0.3802
40° 0.3636
50° 0.3351
60° 0.2804
70° 0.1195
0° GROUND SITE LATITUDES
20°
30°
40°
50°
60°
70°
FRACTION OF TIME THAT ELEVATION ANGLE IS ≥ φ CONDITIONAL ON ELEVATION ANGLE ≥ 10°
ELEVATION ANGLE φ (deg)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
10
20
30
40
50
60
70
80
90

Fig. 2

DISTRIBUTION

G. P. Dinneen
W. E. Morrow, Jr.
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13. ABSTRACT

There is interest in determining the distribution of look angles to a near synchronous equatorial satellite for ground stations at various latitudes. A computer program was written to determine these distributions with ground station latitude and minimum acceptable look angle as parameters.

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